HydraterraProfessionals LLC
Water Resource Engineers & Consultants

TECHNICAL MEMORANDUM

TO: **City of Reading, PA**
Fritz Island WWTP

FROM: **Milissa Hirst**

SUBJECT: Sixth and Canal Phase II Improvements
Option 4B and Option 5
Cost Evaluation of Replacing Steel Force Main

DATE: 6/10/15
Updated 6/22/15

cc: file

The Sixth and Canal Pumping Station conveys the majority of the City's wastewater to the Fritz Island WWTP. The wastewater is conveyed from the pumping station along the Schuylkill River, approximately 6,000 linear feet, through a 42 inch ductile iron force main. In 2011-12, the City constructed the 42-inch diameter DI force main parallel to the existing 42-inch steel force main, which had failed at two locations.

RK&K has been retained by the City to design Phase II Improvements to the 6CPS, which includes improvements to the pumping units. During the performance of this work, the question has been raised whether the pumps should be designed with one or two force mains in service. In order for two force mains to be operable, the 42-inch steel force main will require replacement.

RK&K has developed 7 options for the replacement of the pumping units. Two of the options considered the use of one force main while the remaining five options considered both force mains to be in service. The two single-force main options (Options 1 and 5) were the most expensive.

Of the seven options investigated, the preferred alternative was narrowed to down to two options:

Table 1 – Summary of Selected Alternatives

	Option 4B	**Option 5**
Description	60MGD with 6 Shafted Pumps Using Both Force Mains	60MGD with 2 Shafted Jockey Pumps and 4 Shafted Larger Pumps Using One Force Main
Firm Capacity [1]	65MGD at 60feet TDH	52 MGD at 115 feet
Total Estimated Construction Cost	$8,787,130	$16,356,730

[1] – Pumping capacity with largest pumping unit out of service.

The cost differential between the two options is substantial. Table 2 provides a summary of the key cost differences.

Table 2 – Summary of Cost Differences		
	Option 4B	**Option 5**
Total Estimated Construction Cost	$8,787,130	$16,356,730
Cost of Pumping Units	$1,108,800	$3,465,000
Electrical Construction Cost	$5,200,715	$9,254,265
Comments	The construction cost does not include the replacement of the 42-inch diameter steel force main.	The pumping units are larger horsepower and will require a major upgrade to the electrical service.
		Cost does not include work associated with constructing a location on the site for the installation of the proposed generators (which will no longer fit inside the existing generator room)
		Cost does not include potential structural modifications to support the weight of the larger horsepower motors.

In order to provide an apples-to-apples evaluation of the alternatives total project costs were developed for each Option. The total project cost include construction, engineering and construction management.

For Option 4B, the cost for the replacement of the 42-inch diameter steel force main was developed using the bidding costs from the construction of the 42-inch diameter ductile iron force main. Similarly, the engineering costs for the design of the force main replacement were estimated using the same ratio of design fee to construction cost that was used for the design of the 42-inch force main.

In order to operate the secondary force main, it was assumed that at least one 42-inch plug valve on each force main will need to be electrically actuated. Upon increasing flow rates, the secondary force main would be brought into service by opening the plug valve on that main. For the purposes of this technical memorandum, it was assumed that the actuators would be installed on the plug valves immediately upstream of the flowmeters at Sixth and Canal Pumping Station where the restoration would be accomplished by grading and seeding (not paving). The actuated plug valves would need a vault installed around them to protect the actuators. The vaults would not have heat or lighting and are assumed to be about 10-feet long by 10-feet wide by 10-feet deep.

For Option 5, construction costs for the generator's foundation slabs and reinforcement of the pump station floor slab for the larger motors were estimated. The associated engineering fees were also estimated based on the anticipated manhours.

For both Option 4B and Option 5, the construction management cost was estimated as 5% of the construction cost.

Table 3 provides a summary of the estimated total project costs.

Table 3 – Estimated Total Project Cost Estimates		
	Option 4B	**Option 5**
Total Estimated Construction Cost (RK&K)	**$8,787,130**	**$16,356,730**
Additional Items Not Included in RK&K Construction Costs		
Generator Foundation Slabs		$150,000
Floor Slab Reinforcement for 450HP Motors		$100,000
Replacement of 42-Inch Diameter Steel Force Main	$6,747,404	
Add Actuators to 2 Plug Valves including Valve Vaults	$170,000	
Subtotal Additional Construction Items	$6,917,404	$250,000
Subtotal Estimated Construction Cost	**$15,704,534**	**$16,606,730**
Additional Engineering Fees		
Replacement of 42-Inch Diameter Steel Force Main	$792,522	
Add Actuators to 2 Plug Valves and Valve Vaults	$30,000	
Generator Foundation Slabs – Structural & Geotechnical		$30,000
Generator Foundation Slabs – Permitting and FEMA Flood Plain		$25,000
Generator Foundation Slabs – Civil/Site – E&S		$20,000
Floor Slab Reinforcement for 450HP Motors - Structural		$20,000
Upgrade to 4000 Amp Electrical Service		$20,000
Subtotal Additional Engineering Fees	**$822,522**	**$115,000**
Construction Management Fees (5% of Construction Cost)	**$785,226**	**$830,000**
TOTAL ESTIMATED PROJECT COST	**$17,312,283**	**$17,551,730**

Annual Operating Costs

In addition to the capital construction costs, the average annual operating costs were calculated over the 20 year period 2016-2035. In order to develop the operating costs for the pumping units, the flowrates over the 20 year period were estimated by evenly distributing the increase in flow across the period using the numbers provided in the Sixth and Canal Capital Improvements Plan developed by Hazen and Sawyer.

Table 4 – 6CPS Project Flowrates				
	2006-2009		2035	
	MGD	GPM	MGD	GPM
Minimum Day	7.4	5139	10.9	7558
Average Annual	11.9	8264	17.6	12190
Maximum Month	23.7	16458	34.9	24257
Maximum Day	38.8	26944	52.7	36569
Peak Hour	55.3	38403	61.4	42664

In order to determine the cost of the pumping, the frequency of each type of flowrate was estimated and the cost per kilowatt hour was estimated starting with a base rate of $0.055/kWh and increased 6% per year. The minimum day flow was also considered the daily overnight low flow.

Table 5 – 6CPS Flowrate Frequency		
	Frequency	Annual Hours
Minimum Day	0.21	1825
Average Annual	0.67	5891
Maximum Month	0.08	730
Maximum Day	0.03	288
Peak Hour	0.003	26

For option 4B, it was assumed that the second force main would be brought into service for the maximum day and peak hour flow events to reduce the headloss on the pumping units. For Option 5, only one force main would be in service.

Table 6 - Option 4B - Annual Average Pumping Cost									
# of Pumps Operating	Q per pump	TDH per pump	Speed	Efficiency	HP per pump	HP with Efficiency	Frequency	Annual Hours	Annual Average Pumping Cost
1	6633	32	540	0.7	52.22058	75	0.21	1825	$ 10,270.25
2	5350	40	520	0.72	46.63054	65	0.67	5890.72	$ 57,558.69
3	7100	65	680	0.74	104.2767	141	0.08	730	$ 23,279.53
4	8000	52	680	0.7	104.2767	149	0.03	288	$ 12,945.42
5	7500	60	720	0.73	123.7821	170	0.003	26.28	$ 1,680.76
									$ 105,734.65

Table 7 - Option 5 –Annual Average Pumping Cost

# of Pumps Operating	Q per pump	TDH per pump	Speed	Efficiency	HP per pump	HP with Efficiency	Frequency	Annual Hours	Annual Average Pumping Cost
1	6633	32	680	0.74	63.78121	86	0.21	1825	$ 11,865.84
2	5350	40	680	0.75	63.78121	85	0.67	5890.72	$ 75,579.57
3	7100	65	800	0.7	161.2301	230	0.08	730	$ 38,051.07
4	8000	100	920	0.75	245.2109	327	0.03	288	$ 28,412.24
5	7500	120	940	0.8	261.5531	327	0.003	26.28	$ 3,240.71
									$ 157,149.43

Table 8 – Comparison of Estimated Pumping Cost

	Option 4B	Option 5
Average Annual Pumping Cost	$ 105,734.65	$ 157,149.43
Total Pumping Cost 2016-2025	$ 2,114,692.95	$ 3,142,988.64